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**A Study of the 'Industrial Factor' in the Rheumatic**

**Diseases: with special reference to**

**Chronic Arthritis.**

by

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CHAPTER 1. Introduction.

The 'industrial factor' defined and explained.

Many causal factors enter into the production of illness and disease. These factors may be analysed under the headings of personal, industrial or social factors. Industrial factors may be defined as the causal factors which result from conditions operating during the course of occupation.

The study of the 'industrial factor' has grown increasingly important with the development of modern industry and has made marked progress during recent years. It is now realised that Industry is responsible, not only for a number of defined and Scheduled Diseases and Toxaemias of Occupation (of which Silicosis and Lead Toxaemia are examples), but that Industry is partly responsible also for much disease that has not hitherto been recognised as being the consequence of occupation.

For example, if a fisherman contracts Tuberculosis it is unlikely that a significant and strictly occupational factor will be discovered in his case: if, however, a metal worker develops the same disease, it is more than probable that an occupational factor of significant importance could be found. Even if it were possible to demonstrate that the metal grinder had never been exposed to silica dust at his work, the possibility that some factor, incidental to the occupation, was not present could not be dismissed from our minds.

It follows, therefore, that one of the most important tasks before Industrial Hygienists at the present time is to learn to discriminate - and if possible to measure - the



importance of the industrial factor in the causation of disease.

Methods available for the study of the industrial factor.

The discrimination of the industrial factor and the measurement of it are by no means the same thing, although the same methods of enquiry are used for both purposes. There are three methods available to help us to discriminate and measure the causal factors in disease. They are:-

1. Clinical observation and intuition.
2. Statistical study.
3. Animal experimental research.

In the exact measurement of the industrial factor, we have to rely chiefly upon statistical and experimental methods. Clinical study is more valuable for the discrimination than for the measurement of the industrial factor. Clinical observation frequently suggests to medical observers that a certain problem exists; it may even indicate the probable solution of it; but either statistical or experimental methods are required to confirm, refute or modify theories or solutions based upon clinical observation and intuition alone.

The origin of the enquiry.

During the ordinary course of his departmental work, the writer was asked about twelve months ago by a member of the British Committee of "La Ligne contre le Rheumatisme" whether evidence existed which would connect the aetiology of the Rheumatic Diseases with Occupation. The present paper is the direct outcome of that enquiry.

The methods of study selected.

The Rheumatic Diseases as they occur in Industry cannot be easily studied in the Laboratory. Apart from other considerations, the long period of time that would be needed for the necessary experimental work precludes animal experiment; hence only clinical and statistical methods were available for this study. The limits to the value of the statistical method are well known; they are referred to in detail later; but within those limits the statistical method is very valuable. Provided that the statistics are sound in themselves and are interpreted in the light of clinical experience, their findings are trustworthy.

There are then three classes of material available to the Industrial Hygienist who is interested in the study of the industrial factor in diseases like the Rheumatisms, namely:

1. Clinical observation and experience in Industry.
2. Occupation Mortality statistics.
3. Occupational Morbidity statistics.

In this paper some use is made of each of these classes of material.

The aims of the enquiry.

During the course of this study two lines of enquiry suggested themselves.

1. Are there any strictly occupational factors in the aetiology of the Rheumatic Diseases; if so, can the nature of these factors be ascertained?
2. Are there any causal connections between Occupation and the Chronic Arthritic Diseases; and if so, what are they?

The Industrial and economic aspects of the enquiry.

Apart altogether from the medical importance of these questions, there are certain industrial and economic reasons why an answer to them should be sought. During recent years 'Occupation' has been blamed for the large amount of disability which results from the Rheumatic Diseases and for the economic and social losses occasioned by them. But when an attempt was made to prepare a statement of the evidence concerning the aetiological connection between the Rheumatic Diseases and Occupation, it was found that the available evidence was neither convincing nor satisfactory.

In 1924 the Ministry of Health published a report on "The Incidence of the Rheumatic Diseases"<sup>(1)</sup>. The material used in that study was derived from an analysis of the Insurance Records of a number of General Practitioners in various parts of the country. This report attracted attention to the 'industrial factor' in the aetiology of the Rheumatic Diseases. "In this country" the Report says, "the records of a large Approved Society ... showed that approximately one seventh of the payments made in a certain period were due to one or other of the group of affections that are broadly designated 'rheumatic'." (p.3.)

In 1928 Sir W. S. Kinnear delivered a lecture upon "The cost to the country of Industrial Rheumatism".<sup>(2)</sup> He estimated that the cost of Rheumatism was no less than £17,000,000 per annum. At the same Conference, Dr. H. B. Brackenbury<sup>(3)</sup> also read a paper upon the organisation of medical treatment for industrial rheumatism. After 1928 Industrial Rheumatism began

to lay claim to a separate existence of its own.

In 1930 Dr. J. Alison Glover delivered his Milroy Lectures on the incidence of Rheumatic Diseases etc.<sup>(4)</sup> in which he stated that it is "estimated that the total sick benefit paid to the insured workers on that score (i.e. for rheumatic disabilities) amounted to nearly £2,000,000 and that over 3,000,000 weeks of work were lost each year".

The subsequent literature frequently referred to industrial rheumatism and showed that a clear distinction was not always made between rheumatism occurring in industry and the rheumatism directly determined by occupation, either wholly or in part.<sup>(5)</sup> This confusion has been especially apparent in non-medical publications, in which it has been implied that Industry ought to shoulder the entire financial burden of industrial rheumatism irrespective of whether or not the disability could reasonably be attributed to occupational influences.

It is clearly a matter of great practical importance therefore that an effort should be made to estimate the importance of the industrial factor in the aetiology of the Rheumatic Diseases and to discover which are the occupations in which harmful industrial factors are at work. Modern Industry is ready, no doubt, to accept the responsibility for the illnesses which are due to occupation, but it should not be expected to bear the whole burden of diseases that are essentially personal and social in origin.

Glover's classification of "The Rheumatic Diseases".

As soon as a start was made in this study of the Rheumatic Diseases, the apparently insuperable difficulty was

encountered of defining or classifying them. The Rheumatic Diseases constitute a complex group of disorders which show a varied symptomatology, incidence, clinical course and severity. 'Rheumatism' is a convenient clinical label rather than a nosological entity.

In 1924 in Report No. 23<sup>(1)</sup> prepared by the Ministry of Health, a scheme for the classification of the Rheumatic Diseases was adopted (p.10). This classification was also followed by J. Alison Glover in his Report to the Ministry of "Chronic Arthritis" in 1928 (p.3.),<sup>(6)</sup> and is now general adopted with certain modifications.<sup>(7)</sup> In this classification three types or categories of Rheumatic Disease are recognised, namely:

1. Rheumatic Fever and its sequelae.
2. The non-articular rheumatic affections.
3. The chronic arthritic diseases.

This classification is adhered to in this study.

#### The Relationships between the Rheumatic Diseases.

It is still a matter of dispute whether or not these three groups of disease are either causally related to each other or are different manifestations of a common diathesis. Clinical observation suggests that a relationship does exist. There is some definite evidence to support the belief that they are either inter-related or even causally connected. Thus clinical observation suggests that chill, exposure and damp can precipitate or exacerbate attacks of all three types of Rheumatic Disease. Again "sub-cutaneous nodules have been observed in cases of arthritis which are closely similar in histological appearance and



clinical symptomatology to those which are found both in acute rheumatism and in rheumatic fibrositis."<sup>(9)</sup>(p.6.) If an aetiological 'common factor' between the three types of Rheumatic Disease could be proved to exist, this would be a matter of both practical and scientific interest. It would also be important in the interpretation of the results of this present study. If it could be shown that similar conditions predispose to, or determine, both the arthritic and the fibrositic rheumatisms, we should be justified in inferring that any positive conclusions which might be established by the part of this study which deals with the Occupational Mortality Rates from Chronic Arthritis, would be applicable also to the Fibrositic Rheumatisms. But in the present state of our knowledge we are not justified in transferring the results obtained from a study of one group of Rheumatic Disease to either of the other groups.

1. Occupations that involve repeated shocks or movements, or prolonged stress, e.g. compressed-air tool workers, pneumatic drills, cobblers, etc.
2. Occupations that expose the workers to the absorption of lead, e.g. painters, lead-battery workers, etc.

The first three of these groups of occupations are constantly used in the literature as descriptions of risk in connection with rheumatism. The fourth group (lead) is not always included. In 'Occupation and Health', an *International Journal of Hygiene, Pathology and Social Welfare* published by the International Labour Office in 1934,<sup>(10)</sup> it is stated: "Occupations involving hard physical work with exposure to lead workers' occupations,

CHAPTER 2.      The material studied.

Against this background we will enquire whether we can discover any evidence of a positive connection between occupation and Rheumatic Disease, using all of the material available to us.

The clinical evidence surveyed.

Clinical experience (as recorded in the literature) shows that the occupations in which the Rheumatic Diseases are believed to be most prevalent are:-

1. Occupations that involve exposure to damp and to extreme changes of temperature. e.g. farmers, brewers, casual labourers, dockers and out-of-doors workers.
2. Occupations that involve heavy manual labour, e.g. quarrymen, porters, miners, heavy metal workers, etc.
3. (It frequently happens that heavy manual work is carried on out-of-doors.)
3. Occupations that involve repeated shocks or movements, or prolonged pressure, e.g. compressed-air tool workers, pneumatic drills, cobblers, etc.
4. Occupations that expose the workers to the absorption of lead, e.g. painters, lead-battery workers, etc.

The first three of these groups of occupations are constantly named in the literature as Occupations of Risk in connection with Rheumatism. The fourth group (lead) is not always included. In 'Occupation and Health', an encyclopaedia of Hygiene, Pathology and Social Welfare published by the International Labour Office in 1934,<sup>(8)</sup> it is stated: "Generally, hard physical work with exposure to bad weather conditions,

draughts, wind, rain, dampness and high temperature, is a predominating factor for rheumatisms. As a matter of fact this affection is often met with in bakers, stokers, laundry women and land workers, and among the latter chiefly in the form of lumbago." No evidence is presented to support these generalisations.

Within these four groups of occupations of risk a very large number of separate occupations are included. In a booklet "Occupation Hazards and Diagnostic Signs"<sup>(9)</sup> published recently in the United States by the Bureau of Labor Statistics, Dublin and Vane analysed over 1,000 different occupations which cover the entire field of modern industry. Each occupation is analysed according to "the symptoms or conditions or disease to be looked for" in each case. We find that rheumatic affections of one kind or another are stated to be found in no less than 297 of these 1,000 occupations. This number does not include the large group of 150 occupations in which a lead risk is known to be present. (p.39. loc.cit.)

The evidence for the occupational connection between rheumatism and lead is stronger than is usually supposed. Gout in particular is a recognised cause of disability among old lead workers. Thus in her book "Industrial Poisons in the United States,"<sup>(10)</sup> Alice Hamilton, who is a recognised Industrial Medical authority, quotes L. Tanquerel (1850) with approval and in supporting his observations remarks that the "connection between lead and rheumatism is frequently overlooked". (p.103.loc.cit.) Again, J. Alison Glover<sup>(6)</sup> writes "Painters from their special liability to lead poisoning are undoubtedly specially subject to gout

and to osteo-arthritis, and possibly also to rheumatoid arthritis".

(p.19) In the writer's own 24 years of clinical experience the association of the Rheumatism with out-door manual labour <sup>with lead exposure</sup> is clear.

Summarising the available clinical experience concerning the connection between Occupation and Rheumatic Disease, we must admit that while it is vague and uncertain and will not carry us far, nevertheless it does indicate the general types of occupation in which a significant industrial factor may be expected to be observed.

The figures upon which this opinion is based do not carry conviction. The same applies to the figures published by Chas. W. Stanley, based on an analysis of the records of the Dorchester Hospital, Dorset. He remarks that "general and agricultural workers working out-of-doors suffer heavily from fibrositis".

(p.504) The foreign literature also did not appear to be useful for statistical purposes.

#### Scarcity of comparable sickness records in industry.

One of the great difficulties in discovering the amount of the occupational incidence of rheumatism from the Rheumatic Diseases arises from the fact that in industry accurate and statistically comparable sickness records are not being kept. In their study of "Sickness Absence and Labour Wages" (13) Mr. Smith and Margaret Leiper remark that "a firm may keep records for its own purposes but there is no standard by means of which it

CHAPTER 3.      The Morbidity Statistics.

The literature reviewed.

A careful survey of the literature failed to reveal any Morbidity Statistics that were useful for our purpose. From time to time a considerable number of studies have been published, but the material is difficult to interpret. Thus in the Ministry of Health Report No.23 <sup>(1)</sup> referred to above, we read "the difficulties of estimating the effect of occupation upon the incidence of rheumatic disease in such an enquiry as this are well nigh insuperable". (p.35) Templaar and van Breemen <sup>(11)</sup> formed the opinion that men practicing their trades out-of-doors have three to five times more rheumatic abnormalities than others, but the figures upon which this opinion is based did not carry conviction. The same applies to the figures published by Chas. W. Buckley, based on an analysis of the records of the Devonshire Hospital, Buxton. <sup>(12)</sup> He remarks that "general and agricultural labourers working out-of-doors suffer heavily from fibrositis". (p.594) The foreign literature also did not appear to be useful for statistical purposes.

Absence of comparable sickness records in Industry.

One of the chief difficulties in discovering the amount of the occupational incidence of disablement from the Rheumatic Diseases arises from the fact that in Industry accurate and statistically comparable sickness records are not being kept. In their study of "Sickness Absence and Labour Wastage" <sup>(13)</sup> May Smith and Margaret Leiper remark that "a firm may keep records for its own purpose but there is no standard by means of which it



can be judged whether the amount of absence in a particular case" (or we might add, on account of a particular disease) "is high or low for the class of work, nor what are the factors, general and particular, that have contributed to the result." (p.2.)

In the Department of Industrial Hygiene and Medicine in the University of Birmingham we are at present attempting to establish a uniform system of sickness recording upon a basis suggested to us by Dr. May Smith, in a number of large industrial firms in the Midlands and elsewhere. When this work has had time to develop, statistical evidence of the occupational incidence and disability periods of the Rheumatic Diseases and other general diseases, may become available in connection with a variety of industries.

Some statistical material obtained.

The writer was fortunate enough, however, to be given access to the existing sickness records of a large Midland manufacturing firm with a view to ascertaining whether reliable data concerning the relation of occupation and rheumatism could be discovered in them. In this firm, every case of sickness absence which disables a worker for three days or more is personally examined by the Works Medical Officer as a matter of routine. In each case the diagnosis is confirmed by him. There is every reason, therefore, to rely upon the correctness of the diagnosis. This factory is engaged in the manufacture of Food Products. It employs about 9,000 workers; but since the numbers of persons employed and since the relative numbers of men and women employed do not remain constant throughout the year, accurate incidence

and severity rates cannot be calculated. It may be remarked, in passing, that by means of certain relatively simple alterations in the methods adopted by this firm for recording sickness absence, and especially by a standardisation of those methods in different factories, accurate Morbidity data for certain grouped types of sickness could be obtained. This should be the practical outcome of Smith and Leiper's report.<sup>(13)</sup>

#### Occupations and conditions of work.

The occupations carried on in this factory are for the most part 'light', skilled or semi-skilled, and repetition occupations. Wages are high and environmental conditions excellent. For the present study, a three-year period (1934-36) was selected. All cases of incapacity (three days or over) from the Rheumatic Diseases were extracted from the Sickness Records. This work was undertaken by the clerical staff of the factory. The occupation, sex, diagnosis and actual number of working days lost were tabulated for us in each case. It will be observed that the amount of material in these statistics that is useful for our purpose is, however, limited.

#### The case-incidence of the Rheumatic Diseases.

It was found that in this factory 414 persons (male 205, female 209) were incapacitated by one of the three types of Rheumatic Diseases (Glover's classification)<sup>(1)</sup> during the three years 1934-36. This is an average of 138 persons per annum.

From these figures an approximate estimate may be obtained of the actual case incidence of the Rheumatic Diseases in a particular factory in which, during repeated visits to the works,

we have failed to detect any unsatisfactory environmental conditions, and in which neither damp, exposure, extremes of heat, repeated shock, frequent traumata or lead toxaemia are experienced by the workers. Indeed, this factory is emphatically one in which no important occupation factor would be expected to be present.

In this favourable situation we found, nevertheless, that on the average 138 persons were disabled each year from one of the Rheumatic Diseases. This gives a Crude Annual Rheumatic Morbidity Rate of 15.3 per 1000 employed per annum. This figure may be compared with that given in the Ministry of Health Report No.23<sup>(1)</sup> (Table V. p.22-3). "In an estimated population at risk of 58,000 males, 1,771 cases of Rheumatic Diseases were observed. This yields a crude incapacity rate of 30.5 per 1000 at risk". No conclusion can be drawn from the observed differences between these rates because the two groups are not strictly comparable. The observed differences are consistent however, with the hypothesis that in a hygienic and well managed indoor factory, the Rheumatic Diseases are relatively infrequent. They also indicate that even under the best conditions a substantial amount of incapacitating Rheumatism is experienced.

The amount of time lost.

Proceeding with the analysis, it was found that 409 of these incapacitated persons lost a total of 11,138 days of work between them. This gives an average of 27.3 days lost per incapacitated person.

When the cases were analysed into 'long-term' and

"short-term" absences, it was found that:

1. 314 cases of "short-term" absence from Rheumatism lost a total of 3,285 days, i.e. an average of 10.4 days per person.
2. 100 cases of "long-term" absence lost a total of 7,908 days, i.e. an average of 79.08 days per person.

The criterion by which "short-term" absence was separated from "long-term" absence was that used by May Smith and Margaret Leiper<sup>(13)</sup>, (loc.cit. p.15) viz:

Short-term absence up to and including 28 days.

Long-term absence 29 days and over.

Comparison with other Morbidity Statistics.

For comparison with these figures, we are able to quote some figures for the year 1926 privately communicated to us by the Chief Medical Officer of the Post Office. "The figures then showed" he writes "that under an inclusive heading of medical certificates for rheumatism, synovitis, arthritis, myalgia, muscular rheumatism and sciatica, 47,316 postmen incurred 65,110 days sickness absence; 60,034 all other male staff incurred 53,321 days sickness absence; and 32,763 women employees of the Post Office incurred 14,311 days sickness absence. Table A. summarises the results of a comparison of these groups with the Food Factory group.

In interpreting this Table A. caution is needed. It will be observed that only the last two groups (Other male Post Office employees, and Postmen) are comparable in respect of sex. Moreover, statistically significant deviations from what might

TABLE A.

Sickness from the Rheumatic Diseases.

Population at Risk.	Days lost.	Crude Rate per person per annum.	Calculated or expected loss, days.	S.E.= $\frac{100}{\sqrt{C.loss.}}$	Observed Loss $\frac{S.Error.}{S.E.}$
27,000 (Food Factory, m.& f.)	11,138	0.41	23,220	0.66	0.62
32,763 (P.O. employees, m.& f.)	14,311	0.44	28,186	0.63	0.69
60,034 (P.O. employees, m.)	53,321	0.89	51,629	0.44	2.01
47,316 (Postmen, m.)	65,110	1.38	40,691	0.49	2.82
167,113 workers. (Total)	143,880	0.86	-	-	-



be expected as a result of the operation of the laws of chance are only present in the last two groups. Finally, the periods under survey are not contemporaneous.

It may be remarked, however, that in economic status, all three Post Office groups and the Food Factory group are roughly comparable and that the working conditions of Post Office employees are generally excellent.

Interpretation of the evidence concerning 'time lost'.

The figures set out in Table A. may be considered to support the following interpretations:

1. Postmen whose work exposes them to the climate, show a higher average of number of days lost from sickness incapacity on account of the Rheumatic Diseases, than any of the other groups under analysis.
2. So far as reliance can be placed upon the figures and in the occupations studied, the Indoor Food Factory workers showed the lowest average number of days lost on that account.

Statistics of Retirements on account of the Rheumatic Diseases.

From the Chief Medical Officer of the Post Office figures were also obtained showing the numbers of Retirements on account of Rheumatic Diseases in three groups of Post Office workers. A re-examination of the material derived from the Food Factory showed that during the three year period (1934-36) six persons were recorded as having retired on account of Rheumatic Disease.

Table B. has been prepared from these figures. It

TABLE B.

Retirements on account of the Rheumatic Diseases.

Population at Risk.	Retirements.	Crude Retirement Rates per 1000.	Calculated expected Retirements	S.E. = $\frac{100}{\sqrt{C.Ret.}}$	$\frac{Retirements}{Standard Error}$ .
1934-6. 27,000 (Food Factory)	6	0.22	10.8	30.3	0.2
1931-5. 274,904 (P.O. female)	57	0.20	109.6	9.6	5.94
1931-5. 324,957 (P.O. other male)	107	0.33	129.6	8.8	12.2
1931-5. 271,237 (Postmen)	194	0.71	108.4	9.6	20.1
898,098 workers (total)	364	0.40	-	-	-

shows the Crude Retirement Rates per 1,000 employed, the calculated or 'expected' retirement rates in each of the four groups. It will be observed that in respect of retirements from Rheumatic Diseases the same kinds of difference are observed as were observed in Table A. (Sickness Incapacity). The rates are highest for Postmen, and lower in the Food Factory. The lowest figure is that of Female Post Office workers. This may be accounted for by the low average age of female workers. It is a finding upon which no reliance should be placed. (See p.23 below, Age.)

It may be concluded that the observed differences in Retirements from Rheumatic Disease in these groups are consistent with the hypothesis that out-of-doors workers are most severely and frequently incapacitated by the Rheumatic Diseases.

The Incidence of different types of Rheumatic Diseases.

Finally, an analysis was made of the records of the Food Factory to ascertain the relative case-incidence of the three types of Rheumatic Disease with the following results:

	<u>Food Factory.</u>	<u>General Practitioners enquiry. (1) p.20.</u>
(a) Rheumatic Fever & its sequelae.	9 cases = 2.2% of total.	392 cases = 15.6% of total.
(b) The Non-articular Rheumatic Dis.	383 cases = 92.5% of total.	1495 cases = 67.1% of total.
(c) The Arthritic Rheumatisms.	22 cases = 5.3% of total.	623 cases = 24.8% of total.

For comparison, figures quoted in Table 4 of the Incidence of Rheumatic Diseases<sup>(1)</sup> (p.20) are also tabulated.

The population at risk in the Ministry of Health's

enquiry<sup>(1)</sup> (p.14) comprised 90,891 persons of both sexes constituting the total number of insured persons on the lists of 49 insurance practitioners practising in various parts of England. In regard to occupation the report states "It is probable that the metal workers and transportation groups are somewhat over-represented when compared with England and Wales generally. Agriculture is probably somewhat under-represented." (p.16)

No conclusions can be drawn from the figures set out above, although the relatively low percentage of the more severe types of Rheumatism (viz: Rheumatic Fever and Arthritis) in the groups of workers in the Food Factory tends some support to the hypothesis that an industrial factor may partly determine the type of Rheumatic Disease which is experienced.

All of the evidence which is presented above suggests that in the case of the particular firm whose figures we have analysed, any adverse industrial factor is small or non-existent. The conditions in the factory tend to diminish not only the total amount of disability from the Rheumatic Diseases but also the proportion of serious Rheumatism (viz: Acute Rheumatism and Arthritis) amongst its workers. In this particular factory a highly efficient Medical and Health Services have been in operation for a number of years.

#### Conclusions from Morbidity Statistics.

From this survey of these Rheumatic Morbidity Statistics we are entitled to claim support for the views (1) that demonstrable differences in Rheumatic Morbidity Rates exist between occupations, (2) that the material is consistent with the hypothesis that 'exposure' constitutes an adverse occupational influence, and (3)

that even in an optimum industrial environment a substantial amount of Rheumatic Morbidity nevertheless is experienced.

connected with actual mortality from the Rheumatic Diseases and their relation to industrial life.

#### Source of the material.

In as far as mortality experience provides an accurate indication of the non-occupational factors in the aetiology of all kinds of disease, the statistical material published by the Registrar-General in his Decennial Supplement (1911-22) (14) provides about the only available source of material. While it is true that comparative mortality statistics do not necessarily or usually give an indication of the incidence or the intensity resulting from any particular disease among the workers in a given occupation, yet the value of statistics of mortality in reflecting the industrial factor in particular disease may be considerable. It will be able to show that they are not a real value even in the case of disease like the Rheumatic Diseases. It will be observed (see p. 23) that we have been forced to confine this part of our study to the fibrillic group, because it may be said that unless there be a close connection between the Rheumatic Diseases and the Arthritic Diseases (see p. 4 above), a study of the Mortality Rates for the Chronic Arthritic Diseases will seriously underestimate the actual mortality experienced from the Rheumatic Diseases as a whole. Nevertheless, in spite of this and other difficulties (which we discuss below), it was decided to proceed with the study. We were encouraged to do so by the definite evidence of the official statistics that connects



#### CHAPTER 4. The Mortality Statistics.

We shall now discuss the available statistical material connected with actual Mortalities from the Rheumatic Diseases and their relation to occupation.

##### Source of the material.

In so far as Mortality experience provides an accurate indication of the occupational factors in the aetiology of all kinds of disease, the statistical material published by the Registrar-General in his Decennial Supplement (1921-23) (14) provides almost the only available source of material. Whilst it is true that comparative mortality statistics do not necessarily or usually give an indication of the incidence or the incapacity resulting from ~~a~~ particular disease among the workers in a given occupation, yet the value of statistics of mortality in estimating the industrial factor in particular disease may be considerable. We hope to be able to show that they may have a real value even in the case of diseases like the Rheumatic Diseases.

It will be observed (see p.22) that we have been forced to confine this part of our study to the Arthritic group, hence we may be sure that unless there be a close connection between the Fibrositic Diseases and ~~the~~ Arthritic Disease (see p.6 above), a study of the Mortality Rates for the Chronic Arthritic Diseases will seriously under-estimate the actual mortality experienced from the Rheumatic Diseases as a whole. Nevertheless, in spite of this and other difficulties (which we discuss below), it was decided to proceed with the study. We were encouraged to do so by the definite nature of the clinical evidence that connected

certain types of industrial environment with the incidence and severity of Rheumatic Disease, and by the measure of success which has followed the very careful studies published by the Registrar-General of the Comparative Mortality Rates in different occupations and in respect of other types of disease. (14) (p.xvii-xcv).

The results of his work provide a very interesting subject of study to the Industrial Hygienist.

So far as could be ascertained, no previous statistical examination of this material has been undertaken in respect of the Rheumatic Diseases. It was hoped that the new tables based upon the 1931 Census would be available for comparison before this study had been concluded.

It was believed that if a significant occupational factor existed, its presence would be revealed in the mortality experience of the occupations of the whole of England and Wales during the three year period (1921-23). Any factor whose influence was sufficient to affect mortality rates would be expected to be of practical importance.

#### Some fallacies considered.

In a study of this kind, a number of fallacies have to be avoided, the chief of which we will discuss briefly.

##### 1. The Population at Risk.

As Dr. Glover pointed out in his Milroy Lectures (4) ~~that~~ "the assessment of occupational influence and of occupational incidence demands an immense population at risk". The reports of the Registrar-General constitute the only material available in this country which can meet this demand. Evidently the number

of deaths assigned to a particular disease does not provide a necessarily accurate index to the incidence of that disease, nor of the amount of disablement which results from it. There are grounds for believing, however, (see p. 25 below) that the statistics compiled by the Registrar-General do supply reliable evidence concerning both the differential and actual incidence of that group of diseases which are described as 'Chronic Rheumatism, Arthritis and Gout'. Rheumatic Fever and its sequelae are excluded from the material by the Registrar; the Non-articular Rheumatic affections seldom, if ever, cause death.

Not only must the populations at risk be extensive, they must also be comparable in respect of Sex, Habitat, Age, and Social Position. If they cannot be made comparable in these respects, it becomes necessary to enquire what allowance must be made for variations from group to group in any of these four factors.

## 2. Sex.

In regard to Sex the following table shows the actual numbers of Deaths recorded in England and Wales during the years 1931-35 from Chronic Rheumatism etc., Gout. (15)

TABLE C.

Deaths from Chronic Rheumatism etc. Gout.

	1931.	1932.	1933.	1934.	1935.	) Total
Males.	1,163	1,134	1,124	1,140	1,225	) deaths
Females.	2,246	2,294	2,336	2,239	2,342	) at all
						) ages.
						) p.12. (15)

These figures represent a rate of 115 per million of the female population, and 64 per million of the male population of England and Wales.

## TABLE "D"

### Arthritis and All Causes Standard Mortality Ratios and Crude Mortality Rates in Various Occupations (over 45 years), in England and Wales, 1921-23 (Males only).

OCCUPATION GROUP AND NO.	Population 1921 × 3	Deaths from All Causes 1921-3	"All Causes" Standardised Mortality Ratios	Deaths from Arthritis 1921-3	Arthritis Standardised Mortality Ratios	Arthritis Crude D.R. per million	Arthritis Calculated Deaths 1921-3	Standard Error 100 √ C.D.	Difference S.M.R.-100 S.E.
Painters and Decorators (98) .. .. .	214,860	6,617	107.5	59	174.0	274.9	33.9	17.4	4.25
Stable and Garage (111-2) .. .. .	275,025	10,552	130.0	76	170.0	276.3	44.7	14.9	4.70
Miners (Other), (12-15) .. .. .	60,093	2,404	126.0	18	169.8	299.5	10.6	30.7	2.27
Brewers (74-5, 152-3) .. .. .	169,095	7,025	138.0	47	167.0	278.0	28.2	18.9	3.52
General Labourers (164) .. .. .	914,229	39,708	136.2	224	166.5	245.0	134.4	8.6	7.75
Chemical and Dye (25, 64) .. .. .	60,243	1,625	103.0	14	164.7	232.4	8.5	34.4	1.88
Textile Workers (50-63, 65, 68) .. .. .	213,477	8,138	127.5	52	147.7	243.5	35.2	16.8	2.84
Bricks, Tiles and Pottery (17-22) .. .. .	55,065	2,118	138.0	12	145.0	218.0	8.3	34.7	1.63
Docks (117-20) .. .. .	178,515	6,518	138.0	35	136.2	196.0	25.7	19.7	1.84
Heavy Metal (Hot), (27-31) .. .. .	357,987	12,096	108.7	68	110.0	190.0	61.7	12.9	0.91
Warehousemen, etc. (160-2) .. .. .	196,845	5,162	98.5	30	106.0	152.4	28.3	18.9	0.31
All Occupied and Retired Civilian Males ..	12,794,082	409,233	100.0	2,280	100.0	178.2			
Farmers (1 and 5) .. .. .	1,125,987	37,484	81.3	262	99.0	232.0	265.8	16.2	0.06
Light Metal (35-8, 40-1, 44-7) .. .. .	153,090	4,749	106.0	24	98.3	156.7	24.4	20.4	0.08
All Heavy Metal (27-34) .. .. .	753,519	22,795	102.5	120	98.2	159.5	122.1	9.1	0.10
Builders and Bricklayers (90-6) .. .. .	326,838	11,513	105.4	60	97.6	183.5	61.6	12.8	0.19
Commercial Travellers (125, 127, 130-1) ..	256,908	8,855	110.5	42	94.4	163.5	44.5	15.0	0.37
'Bus and Tram Drivers and Conductors (113-15)	97,596	1,518	90.7	7	90.9	71.7	7.7	35.7	0.25
Wood and Carpentry (77-9, 81) .. .. .	439,695	14,788	89.5	85	90.0	193.3	94.4	10.3	0.97
Clerks (132-3, 158) .. .. .	543,999	14,631	89.6	79	87.7	145.0	90.0	10.5	1.17
Heavy Metal (Cool), (32-4) .. .. .	395,532	10,699	97.4	52	87.5	131.4	59.4	13.0	0.96
Builders' and Contractors' Labourers (97, 99)	301,533	9,004	101.0	43	86.8	143.0	49.5	14.3	0.92
Retail Business (123-4) .. .. .	874,833	28,378	98.3	139	86.1	158.8	161.4	7.9	1.76
Railway Workers (105-110) .. .. .	279,927	7,468	90.7	39	86.0	139.0	45.3	14.9	0.93
Miners (Coal), (7-11) .. .. .	727,698	21,473	109.0	89	83.5	122.3	116.6	9.7	1.70
Social Class I .. .. .	380,433	11,782	85.6	63	81.0	166.0	77.9	11.3	1.68
Social Class II .. .. .	2,991,171	98,847	95.9	544	95.0	182.0	572.5	4.18	1.20
Social Class III .. .. .	4,986,732	150,457	96.7	844	98.0	169.5	862.0	3.5	0.57
Social Class IV .. .. .	2,516,145	78,261	97.8	452	103.0	180.0	439.9	4.77	0.63
Social Class V .. .. .	1,919,601	69,886	118.0	377	114.0	196.5	331.4	5.5	2.55

It will be observed, that in general, females died as a result of Chronic Rheumatism etc. Gout, almost twice as frequently as males. Furthermore, we find that as soon as we try to treat females upon an occupational basis, we are unable to do so on account of the uncertain length of the working life of the average woman worker. (14) p.vii. All hope has to be abandoned, therefore, of attempting to assess by means of a study of mortalities the industrial factor (if it exists) in the aetiology of Chronic Arthritis amongst female workers. Hence this part of our study is limited to Male Mortalities only.

### 3. Climate and Habitat.

Climate and habitat might be a seriously complicating factor in the interpretation of any figures which are derived from an industry which was entirely or predominantly located in any particular part of the country. It will be observed, however, that in this present study, care has been taken to avoid this disturbing factor in all of the special groups studied below (see Table D.), with the possible exception of Textiles. The statistical material which is surveyed is derived from England and Wales as a whole.

### 4. Age.

Variations in the age-constitution of the population at risk may seriously upset statistical results. This applies especially to Crude Mortality Rates. For this reason Standardised Mortality Ratios have been used in this study. These Ratios make allowance for the age-constitution of the population at risk and also for the differences in the incidence of death in different



age-groups. The Standardised Mortality Ratios enable us to minimise or to avoid the disturbing effects of the age-constitution of the groups studied; they have been calculated from material contained in the Tables in the Registrar-General's Decennial Supplement, Part II. 1921-3. pp.1-116.<sup>(14)</sup> The possible disturbing effects of the different age-constitutions of the various occupation groups become apparent as soon as we realise that the crude Arthritis Mortality Rates per 100,000 amongst All Occupied and Retired Civilian Males are: 4 at the ages 45-54, 14 at the ages 55-64, 36 at the ages 65-69, and 81 at the ages 70 upwards. As a consequence, in any occupation in which there was a high proportion of elderly workers, we ought to expect a high crude Mortality Rate from Arthritis. The Standard Mortality Ratios are calculated from the following formula:

$$\frac{\text{Registered Deaths} \times 100}{\text{Calculated Deaths}}$$

The Calculated Deaths being found by multiplying 3 x Census population for the occupation at ages 45-54, 55-64, 65-69, 70 and upwards, by 4, 14, 36, and 81 respectively, which are the rates per 100,000 amongst All Occupied and Retired Civilian Males; summing the four products and dividing by 100,000.<sup>(14)</sup> pp.2-116. The Mortality figure for All Occupied and Retired Civilian Males will then be 100.

Again, in the study of a disease or of a group of diseases such as Chronic Rheumatism etc. Gout, another disturbing factor connected with 'age' is encountered. Arthritis, Chronic Rheumatism, Gout seldom appear as a 'registered cause of death' at ages 16-44 years. There is no doubt that the causes of Chronic Arthritis begin to operate in the early years of life, but it does

not appear as a significant cause, even of that small part of the total mortality which is attributed to Arthritis, until the fourth decade is past. Thus out of a total of 2,471 deaths recorded as occurring from Chronic Rheumatism etc. Gout amongst Males over the age of 16 years, during the years 1921-23, only 110 deaths (4.5%) occurred below the age of 45, and 95% occurred above that age. Indeed 40% of the Arthritis deaths actually occurred after the age of 70 years. (14) pp.2-116.

Studies of the age of onset of all varieties of Chronic Arthritis have been made by Pemberton and Peirce (16), who found that the 'peak' period of onset in all of these diseases is between 30 and 50 years of age. As a cause of death, therefore, Chronic Arthritis is predominantly a disease of the later years of life.

While it is true that the method by which the Standardised Mortality Ratios are calculated enables us to make some allowances for this particular source of error, it cannot remove it entirely. Whenever a possible fallacy can be removed at its source, it is well to remove it. For this reason it was decided to limit the present study, not only to registered deaths among male occupied and retired workers, but also to limit it to a study of the deaths which occurred amongst males of the age of 45 years and over.

##### 5. Reliability of the Material.

Another possible fallacy arises from the nature of the material on which the study is based. In his report on Chronic Arthritis (6), Dr. Glover states: "In a study of the prevalence of Chronic Arthritis, we shall obtain little help from Mortality

Statistics, as the sufferers are usually cut off by intercurrent disease". In a foot-note, however, he adds: "This is to some extent compensated for by the method used in the classification of deaths (by the Registrar-General's Department), whereby a measure of preference is accorded to Chronic Rheumatism, Osteo-Arthritis and Gout, these being placed in Group IV of the general diseases, and so, under the present method of working, being preferred to almost any local disease recorded in the same certificate. This practice tends to the approximate completeness of the death returns in respect of Chronic Arthritis." With this opinion we agree. Experience has taught us that Chronic Rheumatism, Osteo-Arthritis or Gout assume a formidable importance in the eye of the practitioner who, for many years, has had charge of the case. Even when the patient dies of some intercurrent disease, it is unlikely that the fact that he had been suffering from Chronic Arthritis will pass entirely unrecorded on the death certificate. If it is recorded, it will be given a 'measure of priority' in the registration.

It may be taken as certain, therefore, that the returns presented by the Registrar-General are reliable indices of the bulk-incidence of that group of diseases which cause death from Chronic Rheumatism, Arthritis, Gout etc. Only one important exception to this generalisation is likely to be of practical importance. In the case of any occupation which shows an unexpectedly low Arthritis Mortality Ratio, we should make sure that a large number of deaths from violence or from diseases which are 'given priority over Arthritis' in the classification of the cause of death, are not being experienced. Violence, Infectious Disease, Cancer or Acute Rheumatism are the most

important of the diseases, the undue prevalence of which, in an occupation, may result in an abnormally low Arthritis Mortality Ratio.

Subject to these limitations (which do not seem to be important in this present study) it would appear that reliable information concerning the effects (if any) of occupation upon that group of diseases which comprise the Chronic Arthritic Diseases can be obtained from the figures presented by the Registrar-General. Whether or not they may be taken to indicate the effects of occupation upon the Rheumatic Diseases as a whole depends upon the view taken of the underlying relationship between the various classes of Rheumatic Disease.

#### 6. Social State.

We have remarked above that it is commonly believed that 'Social or Economic States' are the most important single factor in the determination of differences in the incidence of the Arthritic Diseases. Those who maintain this view hold that the general social conditions of life rather than the strictly occupational conditions of the working life determine the prevalence of Arthritis. Thus, since casual workers are inferior in economic status to skilled mechanics, any differences in their observed Arthritis Mortalities would be attributed on this hypothesis, to their economic and social conditions rather than to the nature of their occupational environment.

A study of the effect of social and occupational state upon mortality from various causes is rendered possible by the alterations which the Registrar-General instituted in the Decennial Supplement, Part II, page viii. (14) "Every occupation

distinguished in the Census has been assigned to one of five Social Classes in Table A. The basis is purely occupational in intention. The new method enables, for example, the head of a tin-plate works to be assigned to his own social class and not to the same class as his labourers. The assignments are, of course, open to criticism, but they do imply that the social class of individuals has been assessed in accordance with the nature of their individual employment. The object in view was not equal distribution of the numbers dealt with, but distinction of the conditions of life. For  $84\frac{1}{2}\%$  of the population, comprised of Classes II-IV, the class variation of All Causes Mortality is almost negligible - merely from 94.2% to 100.7%. It is only at the ends of the scale that the social factor is of much account." The workers whose deaths are analysed in this study belong chiefly to the Social Classes III- V.

Class I. may be described as the Owner-General  
Manager-Professional Class.

Class II. may be described as the Manager-Under  
Manager Class.

Class III. may be described as the Skilled Worker  
Class.

Class IV. may be described as the Semi-skilled (and  
Apprentice) Class.

Class V. may be described as the Unskilled or General  
Labourer Class.

(It appears to be more correct, however, to describe these classes by their numbers than by names which might easily mislead us.)

At the bottom of Table D. the Arthritis Standard Mortality Ratios for the five Social Classes are set out in column 6. The most remarkable feature of these figures is the



uniform incidence of mortality from Arthritis throughout the whole of the employed and retired male population over 45 years of age in England and Wales, when it is analysed upon the basis of Social Class rather than upon the basis of occupation. In these figures we have a 'mass-picture' of the incidence of Arthritis Mortalities amongst the entire employed population when that population is arranged according to earning power rather than according to the actual work performed. It will be observed that in column 9 the Standard Error of each Social Class has been calculated. In column 10 the results of a test for the significance of the Standard Error are set out. These latter figures are reached by dividing the 'observed difference' between the Arthritis Standard Mortality Ratio of each class and 100 (i.e. All Occupied and Retired Civilian Males), by the Standard Error of the Class Standard Mortality Ratio. On this basis only Class V. shows a difference which is more than twice its Standard Error, namely 2.55 and is therefore significant. We shall be justified in concluding, therefore, that with one exception Social Class is not of itself likely to be a finally determining factor in the production of any Arthritis Standard Mortality Ratios which vary significantly from the normal. This exception is provided by those occupations whose workers are drawn chiefly or wholly from Social Class V. (We need not concern ourselves with Social Class I, since none of the occupation groups which are examined below contain many members of Social Class I.) This conclusion will be important when we come to interpret our results.

A study of the composition of Social Class V (in which

deaths from Arthritis are relatively frequent), shows that the great majority of the workers who compose it, are men who work out-of-doors and who are severely exposed to the weather whilst at their work.

7. The Influence of General Mortality Experience upon the Arthritis Mortality Ratios.

As soon as we begin to study the observed occupational differences in the Arthritis Mortality Ratios, we are faced with the fact that these observed differences might be only an expression of the underlying differences in their general 'All Causes' Mortalities. It is known, for example, that the All Causes Mortality Ratio for General Labourers is higher than that for Clerks or for those employed in Retail Business. Might it not be that any observed differences in their Arthritis Mortality Ratios were due to the high mortality experienced by General Labourers from All Causes? We are not at present in a position to discuss this point. It is examined below (see page 35-7).

These then are the chief fallacies which have to be kept in mind in endeavouring to assess the importance of the strictly occupational factors in the production of differences in Occupation Mortality from Chronic Rheumatism etc. Gout, which our study has revealed. It will be clear, we hope, that serious efforts have been made to avoid attributing to Industry a responsibility which properly belongs to the Community as a whole. Therefore any positive conclusions which may be reached should carry more weight. Indeed, it would not be surprising if the results of this study had proved entirely negative and had shown no clear evidence of

specific causal connection between Chronic Arthritis and Occupation. Even a negative result would be of great importance. It would have suggested that Occupation bears no relation to Mortalities from Chronic Arthritis among male workers, and that Chronic Arthritis is essentially a 'social' rather than an industrial disease.

The mortality ratios are set out in detail in Table D. The material from which this Table has been compiled will be found in the Registrar-General's Decennial Supplement, Part II, Mortalities of Males in Several Occupations, 1927-28, pp. 2-115. (14)

It will be observed that the occupation groups have been arranged in order of the severity of their Arthritis Standardised Mortality Ratios, and have been placed above or below All Occupied and Retired Civilian Males, whose mortality experience from Arthritis has been taken as 100 and forms the standard for comparison.

The constitution of the occupation groups.

In Column 2, are the Code Numbers of the Groups which have been chosen for examination. Some of these groups are composite, and a few words must be said concerning the principles which have been followed in their selection. In the Mortality Tables of the Registrar-General, 123 occupation groups are distinguished. The numbers and age-distribution of the Occupied and Retired Civilian Males within the Registrar's groups vary markedly. Bearing in mind the essential importance of 'enormous populations at risk', only certain large occupational groups have been examined. As far as possible, the grouping adopted by the Registrar-General has been followed, but in a number of instances

CHAPTER 5. Occupation Trends in Mortality from Chronic Rheumatism, Arthritis, Gout, etc.

We are now in a position to attempt to interpret the significance of the observed differences revealed by our statistical examination of the Arthritis Standardised Mortality Ratios among Males over 45 years in a number of occupation groups. These Mortality Ratios are set out in detail in Table D. The material from which this Table has been compiled will be found in the Registrar-General's Decennial Supplement. Part II. Mortalities of Males in Several Occupations, 1921-23. pp.2-116. (14)

It will be observed that the occupation groups have been arranged in order of the severity of their Arthritis Standardised Mortality Ratios, and have been placed above or below All Occupied and Retired Civilian Males, whose Mortality experience from Arthritis has been taken as 100 and forms the standard for comparison.

The constitution of the occupation groups.

In Column 1. are the Code Numbers of the Groups which have been chosen for examination. Some of these groups are composite, and a few words must be said concerning the principles which have been followed in their selection. In the Mortality Tables of the Registrar-General, 164 Occupation Groups are distinguished: the numbers and age-distribution of the Occupied and Retired Civilian Males within the Registrar's groups vary enormously. Keeping in mind the essential importance of "enormous populations at risk", only certain large occupational groups have been examined. So far as possible, the grouping adopted by the Registrar-General has been followed, but in a number of instances

it has appeared to be possible to combine together certain groups and thereby to obtain roughly comparable 'populations at risk'. In one or two special instances, smaller groups have been analysed for a particular reason. As examples of smaller groups especially chosen, we may mention Painters and Decorators, and the group Other Miners. This latter group consists of Slate, Iron Ore, Stone, and Tin and Copper Miners and Quarriers. It does not include Limestone Quarriers for a reason which will be evident later. Whatever criticisms may be levelled at the actual grouping of the occupations which we have adopted, it is believed that the constitution of the groups would be generally acceptable to experienced Industrial Hygienists. They have been made upon the basis of a comparable occupational environment.

#### The Arthritis Standardised Mortality Rates.

The Arthritis Standardised Mortality Ratios of each occupation group are set out in Column 6 (Table D.). These figures are the ones upon which our conclusions have been based. In Column 7 the Crude Annual Arthritis Mortality Rates are set out. Wherever these latter rates differ widely from the Standardised Mortality Ratios, we may infer considerable variations from the normal in the age-constitution of the particular group. One case in point is the Farmers group. This observation is referred to later (p. 44). Column 8 shows the numbers of deaths which would be expected to occur in each composite Occupation Group, if the members of the group had actually died from Arthritis at the same rate, age-for-age, as All Occupied and Retired Civilian Males died of Arthritis. Thence, in Column 9 the Standard Error for



each Age Group has been calculated, while Column 10 enables us to see at a glance the 'probable significance' of the observed differences. In those cases in which Column 10 shows a figure greater than 2, we may be sure that the observed differences in the Arthritis Mortality Ratios for that particular group cannot be accounted for by errors due to chance alone. The groups showing a 'significance' of 2 and over are those to which we should pay special attention.

To what then are these observed and apparently significant differences due? Since the groups are essentially occupational in their constitution, there is a prima facie case for supposing that the differences may indicate the presence of occupational factors in their production.

#### Preliminary survey and conclusions.

The first conclusion to be drawn from a preliminary study of these figures is that those forms of Chronic Rheumatism etc. which are registered as 'causes of death', are very uniformly spread throughout all of the occupation groups which are the subject of this study. All of these groups fall within the Social Classes II - V. However important occupation may prove to be in certain special occupations in the production of relatively high mortalities from Chronic Arthritis, it appears that it occurred in 1921-23 at a remarkably uniform rate throughout the whole of the ranks of the employed population in England and Wales (with the possible exception of Class I, whose Arthritis Mortality experience is not examined here.)

#### Six significant occupations.

The second conclusion is that compared with All

Occupied and Retired Civilian Males, there are six occupation groups in which the Arthritis Standardised Mortality Ratios are significantly in excess (i.e. twice the Standard Error or more).

These groups are:- (1) Painters and Decorators; (2) Stable and Garage workers; (3) Other Miners and Quarry workers; (4) Brewers; (5) General Labourers, and (6) Textile workers.

Two other groups fall near to the border-line of statistical significance, viz: (7) Chemical and Dye workers (1.88 times the Standard Error), and (8) Dock workers (1.84 times the Standard Error). It is amongst these six (or at the most eight) occupations therefore that we should look, in the first instance, for evidence of whatever occupational factors may be at work to produce an excess of Chronic Arthritis Mortalities.

#### Low Mortalities.

From the point of view of discovering the occupational causes of Arthritis, any groups which showed a significantly low Mortality Ratio would be very interesting. It will be observed that none of the groups when tested for 'significance' give a figure of twice their Standard Error. The only group which approaches this figure is the Retail Business group (1.78). Within the Retail Business group are included Shop-keepers and their Assistants etc. They are men whose work is carried on indoors. It is interesting also that two groups of workers who are usually believed to suffer excessively from the Rheumatic Diseases show a normal or subnormal ratio. These low ratios are not statistically significant, however. These groups are Coal Miners (83.5) and Farmers (99.0)

#### The effect of 'All Causes' Mortality.

We proceeded to enquire whether the differences which we

had observed in the Arthritis Mortality Ratios (males over 45 years) are such that they could be largely if not entirely accounted for by differences in the 'All Causes' Mortality experience of the occupations themselves? We have already pointed out that All Causes Mortalities vary widely in different occupations. If, on further examination, we found that Arthritis Mortalities varied both in degree and kind concurrently with similar rises or falls in the All Causes Mortality Ratios of each group, this would suggest that the causes of death from Arthritis were general factors (e.g. economic, status, diet, housing, etc.) which may be supposed to determine the 'All Causes' Mortality Rates, rather than specifically industrial factors (e.g. exposure, toxic absorption, strain, etc.) The degree of correlation between the 'All Causes' and the 'Arthritis' Mortality Rates can be measured by calculating the coefficient of correlation between the two rates.

It must be emphasised, however, that in correlating Arthritis Mortality with All Causes Mortality, we are correlating a part with the whole. This procedure will automatically produce some degree of positive correlation, but since the deaths from Arthritis form but a very small fraction of the total mortality (0.55% of Total Deaths, All Occupied and Retired Civilian Males, 1921-23), the amount of correlation due to this cause would be very small. It would be possible to eliminate this small error by calculating the 'All Causes except Arthritis' Mortality Ratio. It has appeared to be unnecessary to do this in this instance.

In Table G. the results of an examination of the measure of correlation between All Causes and Arthritis are set out.

## TABLE "G"

The Correlation between "All Causes" S.M.R.'s and Arthritis S.M.R.'s  
(Males over 45 years) in a number of Occupation Groups (1921-23).

(1) OCCUPATION GROUP. (See Table II).	(2) x=Arth. S.M.R.	(3) y=All Causes S.M.R.	(4) x <sup>2</sup>	(5) y <sup>2</sup>	(6) x minus mean x	(7) y minus mean y	(8) (6) × (7)	(9) (2) × (3) x × y
Painters .. .. .	174.0	107.5	30,276	11,556	55.6	- 1.8	-100.08	18,705.0
Stable and Garage .. .. .	170.0	130.0	28,800	16,900	51.6	20.7	1068.12	22,100.0
Miners (Other) .. .. .	169.8	126.0	28,432	15,876	51.4	16.7	858.38	21,394.8
Brewers .. .. .	167.0	138.0	27,889	19,044	48.6	28.7	1394.82	23,046.0
General Labourers .. .. .	166.5	136.2	27,692	18,550	46.1	26.9	1240.09	22,677.3
Chemical and Dye .. .. .	164.7	103.0	27,126	10,609	46.3	- 6.3	-291.69	16,964.1
Textile .. .. .	147.7	127.5	21,815	16,256	29.3	18.2	533.26	18,831.7
Bricks, Tiles and Pottery .. .. .	145.0	138.0	21,025	19,044	26.6	28.7	763.42	20,010.0
Docks .. .. .	136.2	138.0	18,550	19,044	17.8	28.7	510.86	18,795.6
Heavy Metal (Hot) .. .. .	110.0	108.7	12,100	11,816	- 8.4	- 0.6	5.04	11,957.0
Warehousemen, etc. .. .. .	106.0	98.5	11,236	9,702	-12.4	-10.8	133.92	10,441.0
Farmers .. .. .	99.0	81.3	9,801	6,609	-19.4	-28.0	543.20	8,048.7
All Heavy Metal .. .. .	98.2	102.5	9,643	10,506	-20.2	- 6.8	137.36	10,065.5
Light Metal .. .. .	98.3	106.0	9,662	11,236	-20.1	- 3.3	66.33	10,419.8
Builders and Bricklayers .. .. .	97.6	105.4	9,526	11,109	-20.8	- 3.9	81.12	10,287.0
Commercial Travellers .. .. .	94.4	110.5	8,911	12,210	-24.0	1.2	- 26.80	10,422.2
'Bus and Tram Drivers and Conductors	90.9	90.7	8,263	8,226	-27.5	-18.6	511.50	8,244.6
Wood and Carpentry .. .. .	90.0	89.5	8,100	8,010	-28.4	-19.8	562.32	8,055.0
Clerks .. .. .	87.7	89.6	7,691	8,028	-30.7	-19.7	604.79	7,857.9
Heavy Metal (Cool) .. .. .	87.5	97.4	7,636	9,487	-30.9	-11.9	367.71	8,522.5
Builders Labourers .. .. .	86.8	101.0	7,534	10,201	-31.6	- 8.3	262.28	8,766.8
Retail Business .. .. .	86.1	98.3	7,413	9,662	-32.3	-11.0	355.30	8,463.6
Railway Workers .. .. .	86.0	90.7	7,394	8,226	-32.4	-18.6	602.64	7,800.2
Coal Miners .. .. .	83.5	109.0	6,972	11,881	-34.9	- 0.3	10.47	9,101.5
<b>TOTALS</b> .. .. .	<b>2842.9</b>	<b>2623.3</b>	<b>363,587</b>	<b>293,788</b>	<b>0</b>	<b>0</b>	<b>10612.93</b> <b>418.57</b>	<b>320,977.8</b>
							<b>10194.36</b>	
<b>MEAN VALUES</b> .. .. .	<b>118.4</b>	<b>109.3</b>	<b>15,149</b>	<b>12,241</b>	<b>0</b>	<b>0</b>	<b>424.76</b>	<b>13,374.0</b>

SD x = sq.r. (15,149 - (118.4)<sup>2</sup>) = sq.r. (15,149 - 14,019) = sq.r. 1130 = 33.6 = Standard Deviation of x.

SD y = sq.r. (12,241 - (109.3)<sup>2</sup>) = sq.r. (12,241 - 11,946) = sq.r. 295 = 17.0 = Standard Deviation of y. SDx × SDy = 571.2.

$r = \frac{424.76}{571.20} = 0.74 = \text{Coeff. of correlation. S.E. of } r = \frac{1}{\text{sq.r.}(n-1)} = \frac{1}{\text{sq.r.}23} = \frac{1}{4.8} = 0.21 \text{ Standard Error of coeff. of correlation.}$

$\frac{0.74}{0.21} = 3.52 \text{ times S.E. of } r.$

The conclusion to be drawn from it is as follows: the coefficient of correlation between the various groups in respect of 'All Causes' and 'Arthritis' Mortality Ratios is 0.74, and the measure of its significance is  $3\frac{1}{2}$  times its Standard Error; we must conclude therefore that Arthritis Mortality tends to some extent to vary concurrently with All Causes Mortality and that the factors responsible for the differences in the latter contribute also to the differences in Arthritis Mortality.

Therefore considerable allowance ought to be made for the possibility that social rather than specifically industrial factors determine Arthritis Mortality differences. Caution is needed in the interpretation of our results, especially in those groups which fall into Social Class V, *of which show a high "All Causes" Mortality Ratio.*



CHAPTER 6. Occupations which show Low Arthritis Standardised Mortality Ratios.

None of the occupation groups show a low enough Arthritis Standardised Mortality Ratio to justify us in concluding that specifically favourable occupational influences are at work within them. There are however four occupation groups which show low Arthritis Mortalities to which attention should be drawn, viz: Coal Miners, Farmers, Builders and Contractors Labourers, and Retail Business workers. For reasons which will appear later, we postpone discussion of these groups until the close of the next chapter. It is only necessary to call attention in this place to the fact that except for these four groups, all of the subnormally low Arthritis Mortalities in our Table are found amongst workers who either work indoors or are protected from the worst effects of the elements, whilst on the contrary high Arthritis Mortalities are generally observed amongst outdoor workers.

(a) Stable and Dairy C.

In this group, the All Causes Standardised Mortality Ratio is relatively high, viz. 150.0. They belong to Social Classes III and IV. This group consists predominantly of workers

CHAPTER 7. Occupations which show High Arthritis Standardised Mortality Ratios.

We now turn to discuss those occupation groups which showed a high Arthritis Standardised Mortality Ratio during the period under survey (1921-23).

(a) Painters and Decorators. (see pp.8-10 & 53- )

In this group the 'All Causes Standardised Mortality Ratio' is relatively low (viz: 107.5). Painters belong to Social Class III and Gout and Rheumatism are well known causes of disablement among them. 'Painters Gout' is a recognised clinical entity. Osler quotes Garrod<sup>(17)</sup> as having shown that workers in Lead are especially prone to Gout and says that "in 30% of the Hospital cases of Lead Poisoning, the patients had been Painters or workers in lead." G.Graham writing in Price's Textbook of the Practice of Medicine<sup>(18)</sup> states that lead "seems to be a concomitant cause" of Gout. Of all the known environmental factors to which Painters are peculiarly exposed, there can be no doubt that the slow absorption of small quantities of lead is the one most likely to account for their very high Arthritis Standardised Mortality Ratio. The work of Aub and Minot<sup>(19)</sup> has shown that there is an association between lead and calcium in human metabolism. The importance of these observations will become evident at a later stage of our discussion.

(b) Stable and Garage.

In this group, the All Causes Standardised Mortality Ratio is relatively high, viz: 130.0. They belong to Social Classes III and IV. This group consists predominantly of workers

who drive or care for horses. It may be called the Horse Transport Group, since the numbers of Garage workers included within it are insufficient to alter materially the Arthritis or All Causes Standardised Mortality Ratios. In comparison with the Road Transport group, or with the Railway Transport group, the Arthritis Mortality figures of Horse Transport workers are very high indeed. Whilst it is true that economic position of the Road and Railway workers is superior to that of the Horse Transport workers, the differences in their Arthritis Mortalities is probably too great to be explained by that fact alone. It appears to be probable therefore that some occupational factor is at work upon this group. Considering the nature of their work in all its aspects, it appears reasonable to suggest that exposure to the weather is the most probable aetiological factor.

(c) Other Miners and Quarrymen.

This composite occupation group consists of Iron, Copper, Tin, Stone and Slate Miners and Quarriers. They belong to Social Classes III and IV. Limestone Quarry workers are excluded from it. All Causes Standardised Mortality Ratio for this composite group is 126.0. This figure is relatively high, although it is considerably lower than the All Causes Standardised Mortality Ratio for Dock or General Labourers, whose social position is roughly comparable. (See Table D.) We are probably justified in concluding, therefore, that there is an occupational factor at work to produce an excess of Arthritis amongst this group of workers. The most superficial knowledge of the conditions under which these miners work would suggest that

'exposure to the weather' is the most probable factor concerned.

This group invites comparison with Coal Miners (see below).

(d) Brewers, Cellarmen, Publicans and Barmen.

These workers belong to Social Classes II and IV, and have a significantly high Arthritis Standardised Mortality Ratio of 167.0 and the All Causes Standardised Mortality Ratio is as high as 138.0. Only one other occupation group (viz: Dock Labourers) show so high an 'All Causes' Ratio. In view of the high 'All Causes' Standardised Mortality Ratio and of the known fact that workers in this group have high Mortality Ratios from Nutritional disorders, and from diseases attributed to alcohol, we ought not to conclude (on the basis of our figures alone) that the high Arthritis Standardised Mortality Ratio observed amongst Brewers etc. is necessarily due to occupational factors. Within the industry, however, it is generally believed that Arthritis is unduly prevalent amongst Brewery workers. It is usual to attribute this prevalence to exposure to a damp, humid atmosphere at work. It may be remarked also that Brewers and Textile workers are the only groups of 'Indoor workers' who showed a significantly high Arthritis Standardised Mortality Ratio during the period under survey.

(e) General Labourers.

This group of workers belongs to Social Class V, and shows a relatively high All Causes Standardised Mortality Ratio (136.0). These two facts discount, to some extent, the high Arthritis Standardised Mortality Ratio which the group experienced. General Labourers are essentially Outdoor workers, exposed to damp

and to the full rigours of the climate. No other strictly occupational factor, common to the majority of the members of this somewhat heterogenous group, suggests itself as a probable occupational cause of the high Arthritis Mortality which they experienced.

(f) Textile workers.

The Textile group is the only group of Indoor workers besides the Brewers which shows a significantly high incidence of Arthritis Mortality. Whilst the 'All Causes' Standardised Mortality Ratio is also relatively high (127.5) and whilst the bulk of the workers are drawn from the North of England, where atmospheric humidity is high, it is probably not without significance that their occupation itself necessarily exposes them to the effects of humid atmospheres. At least it may be asserted that humidity is the most probable factor likely to account for the high Arthritis Standardised Mortality Ratio observed in this group during the period under survey.

As a result of our preliminary examination of the occupations which show definitely high Arthritis Standardised Mortality Ratios we have noted: (1) that one group (Painters and Decorators) show a high Arthritis Standardised Mortality Ratio which may be attributed to a specific toxæmia (viz: Lead), and (2) that whilst the significance of the high Arthritis Mortality Ratios observed in the other groups (Stable and Garage, Other Miners and Quarrymen, General Labourers, etc.) may be questionable so long as the groups are considered separately, it is remarkable that all of them, without exception, are either occupations which involve severe exposure to the weather or else are



carried out in damp or humid atmospheres in the factories. Furthermore, in two other groups (Dye and Chemical workers and Dock Labourers), high Arthritis Standardised Mortality Ratios are also observed which approach 'significance'. Many Dye and Chemical workers work in humid (and it may be toxic) atmospheres, whilst the Dock Labourers are exposed to the weather. The case of the Dye and Chemical workers becomes of even more significance when we note that the 'All Causes' Standardised Mortality Ratio in this occupation is as low as 103.0.

Special occupations considered.

It would seem clear, therefore, that the greater part of the occupations which show a high Arthritis Standardised Mortality Ratio are occupations which involve exposure to the weather, or to humid atmospheres at work. No occupations are observed in which a high Arthritis rate occurs in a 'dry' occupation, and the highest ratio observed amongst workers not exposed to damp is found in the Metal workers (e.g. Puddlers, Smiths etc.) who form the Heavy Metal (Hot) group. In this connection it is interesting to observe that in the Report No.23 on Rheumatic Diseases<sup>(1)</sup> p.38, amongst males the outstanding occupational feature is the number of patients in the Metal working group.

There are two occupations (viz: Farmers and Bricklayers) <sup>+ Contractor's Labourers)</sup> in which considerable, if not severe, exposure to damp and weather are experienced, and which, nevertheless, show relatively low Arthritis Standardised Mortality Ratios. These groups at first sight appear to contradict the suggestion that 'damp' and

Arthritis Mortality are causally related. The special 'occupational' factors which may explain the low Arthritis Standardised Mortality Ratio of Farmers, Builders' Labourers, and Coal Miners will now be discussed.

(a) Farmers.

The low Mortality Ratio from Arthritis among Farmers is extremely interesting and is not easy to explain. Clinical experience and the literature concerning the Chronic Arthritic Diseases certainly suggests that Arthritis is very prevalent amongst Farmers. It is worthy to remark that the Crude Arthritis Mortality Rate is high amongst Farmers (232 per million). This probably is a consequence of the fact that the average age of Farmers is high. A large number of elderly farmers produce a large number of actual cases of Arthritis, and may lead clinicians to suppose that Arthritis is unduly prevalent amongst this group of people. (It may be that a similar explanation accounts in part for the supposedly high incidence of Arthritis amongst the well-to-do.) The exposure of Farmers to the weather is undoubtedly severe: they are able, nevertheless, to protect themselves in some measure from rain, and experience shows that a certain amount of alternative indoor work can be done in very wet weather, when many farming operations are in fact suspended.

Furthermore, the All Causes Standardised Mortality Ratio of Farmers is remarkably low (81.3): it is in fact the lowest All Causes Standardised Mortality Ratio observed in any of our groups. This may account, in part, for the relatively low Arthritis Standardised Mortality Ratio. It may be the case also that some positive and beneficial factor is at work within

this group which reduces the numbers of deaths from Arthritis and counteracts the supposed ill-effects of exposure. It is suggested below that this factor is connected with diet, and perhaps especially with Calcium metabolism. Lastly in the Ministry's Report No.23 referred to above, it is observed that 'Agricultural workers are very much below the average in every <sup>(rheumatic)</sup> disease except Rheumatoid Arthritis' (loc.cit. p.38).<sup>(1)</sup>

It is clear that during the period under survey and on the evidence presented here, Farmers experienced a surprisingly low Mortality from Arthritis; nevertheless, it is doubtful whether we are justified (on the available evidence) in concluding that Chronic Arthritis is not prevalent amongst Farmers.

(b) Builders and Contractors Labourers.

This group is discussed below (see p.49 ).

(c) Coal Miners.

The low Arthritis Standardised Mortality Ratio observed amongst Coal Miners calls for comment. Their 'All Causes' Standardised Mortality Ratio is slightly above that experienced by All Occupied and Retired Civilian Males: they belong to Social Classes III and IV. The low Arthritis Standardised Mortality Ratio of Coal Miners may be due to 'chance' (see Column 10). It is undoubtedly due, in part, to the large numbers of deaths from Violence which occur in this occupation (which may account for a 2-3% decrease in Arthritis deaths). It may be due, in part also, to the known fact that a very considerable migration from the Mines of 'lower middle-aged' workers occurred during the war and during the years which followed

the close of the war (1914-1920). This may have disturbed and lowered the Arthritis Mortality (over 45 years of age) in this occupation by the selective elimination of some who would have died of Arthritis during 1921-23. In other words, it is probable that the group 'Coal Miners' is an atypical group. We have endeavoured to discover whether the material at our disposal would enable us to compare the Arthritis experience of Coal Miners, who work in damp mines with that of Coal Miners who work in dry mines, but found it to be impracticable. From the Ministry's Report No.23. we learn that 'Miners and Quarriers show a lower attack rate from all rheumatic diseases than would be expected.' (loc.cit. p.38<sup>(1)</sup>).

Table 2.

Expected and observed Arthritis Mortality.

It is believed that the groups are large and varied enough to make it improbable that they are 'atypical' in respect other than the one factor of exposure to damp and wet. (It is impossible to find any large group of 'atypically typical' outdoor workers, the greater number of whom are employed in Social Classes (3, 4, 5).)

It will be observed that the Arthritis Mortality rate is slightly above the expected rate in the industry group, and below the expected rate in the general population. The expected rate for the general population is based on the mortality rate for all causes, and is therefore a very rough estimate. It will be observed, also, that the Arthritis Mortality rate is slightly above the expected rate in the industry group, and below the expected rate in the general population. The expected rate for the general population is based on the mortality rate for all causes, and is therefore a very rough estimate.

CHAPTER 8. Composite Occupation Groups.

On the basis of this preliminary examination of our mortality material, the hypothesis clearly emerges that the chief occupational factor in the determination of Arthritis Mortality Ratios is 'exposure to the weather and especially to damp' during work. To test this hypothesis three 'Composite Occupation Groups' have been arranged. This has been done by combining a number of the occupation groups contained in Table D. according to whether the occupations entail (a) Severe exposure, (b) Moderate exposure, or (c) whether they are essentially dry, indoor occupations. The results of this examination are tabulated in Table E.

Exposed and unexposed to climatic changes.

It is believed that the groups are large and varied enough to make it improbable that they are 'selected' in any respect other than the one factor of 'Exposure to damp and wet'. (It is impossible to find any large group of 'severely exposed' outdoor workers, the greater number of whom do not belong to Social Classes IV - V.)

It will be observed that the Arthritis Standardised Mortality Ratio is highest in the exposed group, lowest in the indoor group, and only slightly above normal in the moderately exposed group. It need hardly be remarked that Builders and Bricklayers, and Builders and Contractors Labourers do not continue at their work when the weather is very wet. It will be observed, also, that the differences from the average mortality are more than twice their standard errors in both the severely exposed and the indoor groups. The first



# TABLE "E"

## Composite Occupation Groups. (Over 45 years, Males only).

OCCUPATION GROUP AND NO.	Population 1921 × 3	Deaths from All Causes 1921-3	"All Causes" Standardised Mortality Ratios	Deaths from Arthritis 1921-3	Arthritis Standardised Mortality Ratios	Arthritis Crude D.R. per million	Arthritis Calculated Deaths 1921-3	Standard Error $\frac{100}{\sqrt{C.D.}}$	Difference S.M.R.-100 S.E.
<b>SEVERE EXPOSURE TO WEATHER.</b>									
Miners (Other), (12-15) .. .. .	60,093	2,404	..	18	..	..	..	..	..
Stable and Garage (111-2) .. .. .	275,025	10,552	..	76	..	..	..	..	..
General Labourers (164) .. .. .	914,229	39,708	..	224	..	..	..	..	..
Farmers (1 and 5) .. .. .	1,125,987	37,484	..	262	..	..	..	..	..
Docks (117-20) .. .. .	178,515	6,518	..	35	..	..	..	..	..
	2,553,849	96,666	107.5	615	112.0	241.0	509.5	4.44	2.7
<b>MODERATE EXPOSURE TO WEATHER.</b>									
Builders and Bricklayers (90-6) .. .. .	326,838	11,513	..	60	..	..	..	..	..
Builders' and Contractors' Labourers (97-99)	301,533	9,004	..	43	..	..	..	..	..
Commercial Travellers (125, 127, 130-1) ..	256,908	8,855	..	42	..	..	..	..	..
Painters and Decorators (98) .. .. .	214,860	6,617	..	59	..	..	..	..	..
	1,100,139	35,989	105.5	204	106.0	185.5	191.8	7.27	0.83
<b>INDOOR WORKERS.</b>									
Wood and Carpentry (77-9, 81) .. .. .	439,695	14,788	..	85	..	..	..	..	..
Tailors (67) .. .. .	94,146	2,862	..	18	..	..	..	..	..
Retail Business (123-4) .. .. .	874,833	28,378	..	139	..	..	..	..	..
Boot and Shoe Repairers (69) .. .. .	93,000	3,474	..	15	..	..	..	..	..
Clerks (132-3, 158) .. .. .	543,999	14,631	..	79	..	..	..	..	..
Warehousemen (160-2) .. .. .	196,845	5,162	..	30	..	..	..	..	..
Light Metal (35-8, 40-1, 44-7) .. .. .	153,090	4,749	..	24	..	..	..	..	..
	2,395,608	74,044	93.7	390	88.0	162.5	443.0	4.67	-2.57

standardised ratio is significantly high and the second significantly low.

Conclusion.

The results of this examination may be held therefore to support the hypothesis which we have already reached that 'Exposure to weather' is a significant occupational factor in the production of high Mortalities from Chronic Arthritis. And, when taken in conjunction with the observations already made concerning the three 'Indoor' groups with relatively high Arthritis Mortalities (viz: Brewers, Textile workers, and Chemical and Dye workers), may be considered to indicate that a liability to exposure to damp and moisture is an important definite and adverse occupational factor in the production of Chronic Arthritis Mortality amongst males.

CHAPTER 9.      The Hypothetical Relation between Calcium Intake  
and Arthritis Mortalities.

Builders and Contractors Labourers.

We remarked above that during the period under survey Builders' and Contractors' Labourers experienced an Arthritis Mortality which was not only lower than that experienced by Builders and Bricklayers, but was also lower than any of the other Outdoor occupations. It is even lower than many Indoor occupations (e.g. Metal workers, Carpenters, and Clerks). Builders' and Contractors' Labourers and Builders and Bricklayers are exposed to the same industrial environment, and their All Causes Standardised Mortality Ratios differ only slightly (Builders and Bricklayers 105.4, Builders' and Contractors' Labourers 101.0). On general principles therefore, since Builders' Labourers belong to the lowest Social Class (V.), we should expect a higher Arthritis Standardised Mortality Ratio for them than for the Builders. In fact, we observe that the Labourers Arthritis Standardised Mortality Ratio is 11.8% lower than that of the Bricklayers (who belong to Social Class III). Taken by itself, no conclusion could be drawn from this 11.8% difference, but in our detailed study of the Occupational Mortality Tables in the Decennial Supplement, it had already been observed that Lime Workers, Limestone Quarriers and other persons whose work exposed them to various Lime Dusts, experienced remarkably few deaths from Arthritis during the period under survey. For example, the experience of the Limestone Quarriers contrasted very strongly with that of Other Miners and Quarry workers. In the inhalation and presumably the

## TABLE "F"

### Composite Occupation Group of Male Workers Exposed to Lime Dust. (Over 45 years).

OCCUPATION GROUP AND NO.	Population 1921 × 3	Deaths from All Causes 1921-3	"All Causes" Standardised Mortality Ratios	Deaths from Arthritis 1921-3	Arthritis Standardised Mortality Ratios	Arthritis Crude D.R. per million	Arthritis Calculated Deaths 1921-3	Standard Error $\frac{100}{\sqrt{C.D.}}$	Difference S.M.R.-100 S.E.
Lime Burners (16) .. .. .	8,418	207	..	0	..	..	..	..	..
Plasterers (92) .. .. .	27,111	986	..	3	..	..	..	..	..
Limestone Miners and Quarriers (14B) .. .. .	11,424	328	..	4	..	..	..	..	..
Limestone Masons, Cutters and Dressers (94A)	14,679	650	..	1	..	..	..	..	..
	61,632	2,171	..	8	..	129.0	12.2	28.6	-3.07
Builders' and Contractors' Labourers (97, 99) ..	301,533	9,004	..	43	..	143.0	49.5	14.3	0.92
	363,165	11,175	..	51	..	140.5	61.7	12.8	-3.34

absorption of considerable quantities of Calcium could be shown to exert a favourable influence upon the incidence of and mortality from Arthritis, a rational explanation would be found for the observed differences in Arthritis Mortality experienced between Builders' and Contractors' Labourers on the one hand, and Builders and Bricklayers on the other. During their work, Bricklayers handle wet mortar, whilst Builders' labourers inhale considerable quantities of Lime during the mixing of that mortar, and Contractors' labourers during demolition work.

Composite occupation group exposed to Lime Dust.

It seemed to be worth while, therefore, to prepare a Composite Occupation Group of workers 'Exposed to Lime' during the course of their work. This composite group is set out in Table F.

In fact we do observe just such a low Arthritis Rate in the composite occupation group (Table F.). We might infer therefore that the absorption of Calcium as a result of occupation, lessens the effect of a defective calcium intake in the diet and results in the low Arthritis Mortality in an occupation which, on other grounds, was expected to show a high Arthritis Ratio.

\* (See p 51 over).

This inference can be supported both by clinical observation and by the results of the previous analysis. Thus industrial medical and dental experience show that lime workers preserve their teeth longer and in better condition than other comparable workers do. Again the connection (discussed in the next chapter) which exists between Calcium and Lead Metabolism



and between Lead Toxaemia and the gouty forms of Arthritis points in the same direction. Is it not possible also that the relatively low Arthritis Mortality Ratio (Table D.) and the low incidence of the Rheumatic Diseases observed amongst Farmers may be accounted for by a relatively high dietary intake of Calcium?

In view of these observations we must now enquire 'What evidence there is that Arthritic Diseases are causally related to a low Calcium intake?

The Relation between Calcium Metabolism and Arthritis Mortalities.

Opinions are divided concerning the possible connection between Calcium Metabolism and Arthritis. Some authorities affirm and other deny that any relation exists. Poynter and Schlesinger discussing the constitutional disturbances in Arthritis Deformans leave the matter undetermined for all forms of Arthritis. (p.261-2)<sup>(7)</sup>

Builders' and Contractors' Labourers.

Now in the first place we have found a considerable group of workers (Builders' and Contractors' Labourers) whose occupation and social position would lead us to expect a relatively high Arthritis Mortality Ratio. But we observe that their Ratio is very low. We know that their work exposes them to the inhalation of lime dust whilst at work.

In the second place there is reason to believe that the dietary of many, if not most Labourers, is deficient in Calcium. Thus J. Hamburger (quoted by Sollmann p.285)<sup>(20)</sup> states that "there is clear evidence that the average modern dietary is deficient



in Calcium". This opinion is confirmed by Sir John Boyd Orr p.34<sup>(21)</sup>. According to Orr's work only members of the 'higher income' groups obtain an adequate supply of calcium. On these grounds we should conclude that Builders' Labourers take a diet that is in itself deficient in calcium.

Thirdly we must ask whether Lime Dust is absorbed after it has been inhaled into the lungs? Would the inhalation of Lime Dusts tend to correct the presumed calcium deficiency in this group? The absorptive power of the alveolar membranes of the lungs is known to be high for certain chemical substances. Thus the alveolar membrane not only absorbs gases, but it also ~~absorbs~~ absorbs certain solids, like silica and lead oxides; this is particularly the case when the dusts are inhaled in a finely divided or dispersed state. The amount of absorption appears to depend upon the solubility of the particular dust in the body fluids. We can find no records in the literature of experiments to determine the fate of Lime Dust when it is inhaled, but there seems to be little doubt that a considerable proportion of any lime dust that reaches the alveoli and finer bronchial tubes would be absorbed into the blood stream.

If, therefore, we may assume (1) that the lower paid workers usually eat a diet deficient in Calcium, and (2) that Lime Dust is absorbed into the system when inhaled in the air, then if there be a relation between low calcium intake and high Arthritis Ratios, we should expect that these occupations which expose workers to the inhalation of Lime-bearing dusts, would show a lower Arthritis Ratio than other occupations of a comparable economic status. For example, we might compare Builders' Labourers with

Dock Labourers. On this hypothesis we should expect the lime-exposed Builders to show a lower Arthritis Rate than the Dockers. The fact that they do show the expected difference is consistent with the proposition that Calcium deficiency and Arthritis Mortality are related.

Whatever may prove to be the truth concerning the association between Calcium and Arthritis Mortalities, the fact remains that in this composite group of Calcium-exposed workers, an Arthritis Standardised Mortality Ratio of only 82.7 was observed (Standard Error 12.8, measure of significance 3.34 times the Standard Error). This is the lowest Standardised Mortality Ratio that we have found with the sole exception of the Arthritis Standardised Mortality Ratio of Social Class I. in which the Calcium intake is certainly adequate.

#### Conclusion.

We may conclude therefore that this study supports the hypothesis that the differential incidence of Arthritis Mortalities by occupation may be partly determined by deficiencies in the absorption of Calcium, or by the absorption of Lime at work.

#### The Relation between Calcium Metabolism, Lead Absorption and Gout.

We have observed above that Lead workers are believed to be prone to rheumatic disease and especially to gout; that Painters experience a high Mortality Ratio from the Arthritic Diseases, and that there may be a causal connection between a high Calcium Intake on the part of workers exposed to the Lime Dusts

and a low Arthritis Mortality. Finally we assert that there is an intimate connection and relationship between Calcium Metabolism and the pharmacology of Lead. This connection is recognised by Industrial Hygienists. What bearing have these observations upon the aetiology of the rheumatisms and especially what light do they throw upon the relatively high mortality experience of Painters from Arthritis?

We have already referred to this matter above. Here we summarise the evidence which tends to show that there is an intimate connection between Calcium Metabolism, Lead Poisoning, and the Arthritic Diseases of Lead workers. This matter is interesting and important on its own account. It also possesses a collateral interest in so far as it tends indirectly to support the hypothesis put forward in the first part of this chapter, namely, that a high Calcium Intake tends to prevent the development of the arthritic diseases.

There is clear evidence that a high Calcium Intake prevents the development of the toxic effects of Lead. Thus the drinking of milk is an old and well-tried prophylactic against Lead Poisoning amongst Lead workers. Indeed, the provision of milk is a legal obligation upon certain types of lead occupations in the lead working industries. The value of milk has been recognised ever since the 16th. century.

We have already seen that at least the 'gouty' forms of Arthritis are symptomatic of the slow action of lead upon the human body. It is known also that the toxic effects of Lead (e.g. Colic) can be minimised by the absorption of Calcium into

the body. Thus: Aub, Minot et al. <sup>(19)</sup> say "A new treatment for lead poisoning which has proved satisfactory in our cases is based upon the observations of the excretion of lead in ~~in~~ cats and man. The foundation of this is the fact that the quantity of lead excreted may be varied by distorting the Calcium Metabolism and that a positive balance favours the storage of lead, while a negative balance tends to increase the rate of excretion. The association of active symptoms with... an active lead stream... indicates that when symptoms are evident... it is wise to immobilise lead by impeding its liberation from the bones." p.225.

And again the same authority "It has been shown by chemical studies with animals that an analogy exists in the metabolism of Calcium and Lead. Various decalcifying agents have been shown also to increase the lead output. Conversely, conditions favouring calcium retention also tend towards a complete storage of lead in the bones." p.98.

Our own personal industrial experience of the action of lead is derived from the observation of about 100 lead workers during a period of years; it has shown that the onset of an acute illness (such as influenza) may suddenly and unexpectedly precipitate an attack of lead poisoning in a lead worker. That this danger is present is well-known to industrial hygienists. It is always believed to be due to a disturbance of the Calcium Metabolism. Even in cases in which obvious symptoms of lead poisoning do not occur, careful and repeated examination of the blood picture of those workers who happen to have contracted a feverish illness, will frequently reveal a contemporaneous rise in the number of



basophilic-staining red cells in the circulating blood.

Taking all of these points into consideration we may infer that a high Calcium Intake appears to lessen the incidence of and mortality from Arthritis among workers. We may infer furthermore, that the adverse effect of lead may be minimised by a high Calcium Intake and increased either by a low Calcium Intake or by the onset of acute illnesses which tend temporarily or permanently to result in the excretion of considerable amounts of Calcium and thus to lower the Calcium level.

This hypothesis gives a rational and consistent explanation of the high Arthritis Mortality experienced by Painters, and is consistent, moreover, with other hypotheses which have been reached during the present study.

It appears, therefore, that lead poisoning and the 'Arthritis of Lead workers' is related to the wider problems of Calcium Metabolism.

CHAPTER 10.      The relation between non-articular and articular  
Rheumatic Diseases.

The practical importance of determining whether a causal relation exists between the non-articular and articular Rheumatic Diseases was pointed out above. The theoretical interest of this problem is evident. If, moreover, such a connection could be proved to exist, the value of any conclusions reached by this enquiry would be enhanced.

The material presented in the foregoing chapters contains no direct and unequivocal evidence upon this point although the excessive comparative incidence of (a) incapacity, and (b) retirements from Rheumatic Disease amongst Postmen when taken in conjunction with (c) our conclusion that outdoor workers experience in general an over-average incidence of mortality from Arthritis suggests the possibility of such a connection. The Arthritis Mortality ratio of Postmen cannot be independantly calculated from the Registrar-General's Tables because Postmen are included in a larger group of Civil Service Officials and Clerks. (Decennial Supplement, p.77.)

It is possible, however, to compare the results of the occupational analysis of Arthritis Mortality Ratios (Table **D**.) with the results of the occupational analysis of the Morbidity Rates experienced by male patients suffering from the Rheumatic Diseases in the General Practitioners Survey p.35-8.<sup>(1)</sup> When this is done, certain interesting resemblances are observed between the occupational incidence of the Rheumatic Diseases and the occupational mortality ratios.

The simplest way of making the necessary comparisons will be to deal in order with each occupation mentioned in the Ministry of Health Report No.23<sup>(1)</sup>.

(1) Thus on p.38 we read: "The outstanding occupational feature is the number of patients in the Metal Workers (Order 10). As has been stated in a previous section on the population at risk this group is considerably over-represented. Whether the over-representation is sufficient to account for the excess is however doubtful... This excess is practically uniform for each (rheumatic) disease except Rheumatoid Arthritis."

Personal acquaintance with this occupation suggests that considerable allowance should have been made, also for the influence of an exclusively traumatic factor in increasing the incidence of incapacity from the Rheumatic Diseases in this particular occupation. In this occupation slight injuries and strains frequently occur to muscles and ligaments. These slight strains are apt to be recorded as being due to 'muscular rheumatism'. The difficulties of the differential diagnosis are well-recognised and moreover, the questions of compensation and of sickness benefit are frequently involved.

In our opinion the effect of these two considerations would be definitely to lessen but not to abolish the excess of incapacity among Metal Workers observed in the Ministry Report.

In our Mortality Ratios Hot Metal Workers experienced the highest Arthritis Ratio observed amongst Indoor workers, with the sole exception of four groups who work in humid or toxic atmospheres. In our study then the Arthritis Mortality of Metal

Workers was over-average, as also in this group is the incidence of Rheumatic Disease in the Ministry's survey.

(2) In the Ministry Report we read "Workers in Mines and Quarries have probably a correct representation in our sample and show a lower attack-rate than would have been expected." In our enquiry we separated Coal Miners from Other Miners and Quarrymen. This was done because the latter were more exposed to weather than are underground Coal Miners. In our enquiry, however, the group Other Miners is numerically very small. The addition of this small group to our Coal Miners group would not appreciably affect the Arthritis Ratio of our Miners group. Therefore, our group of Coal Miners may be compared with the Ministry's group of "Workers in Mines and Quarries". In our study as we have seen above, this group likewise "shows an unexpectedly low Mortality Ratio" from Arthritis.

(3) Again, in the Ministry Report we read "Clerical workers may be considered to be about average", i.e. for Rheumatic illness. In our study they were just below average.

(4) In the Ministry Report "Workers in Conveyance of men, goods and messages... are not over-represented in the sample". In our study, Transport Workers (both Road and Railway) occupy low places in the list of occupations.

(5) The Report says again "Agricultural workers are very much below average in every disease except Rheumatoid Arthritis". In our figures the Farmers Group (which includes Agricultural workers and is largely composed of them) showed an average Arthritis Mortality Ratio of 99.0, which was very considerably lower than we expected to find.

(6) Finally, there is the category of General Labourers. In the Ministry Report it is stated "in spite of reservation, the incidence on general labourers of every Rheumatic Disease and especially of Lumbago and Rheumatoid Arthritis is excessive." In our study we observed that General Labourers occupied the fifth place from the top in the list of Arthritis Mortality Ratios, and that whilst this was explained in part by their economic position, it was improbable that this was the sole explanation.

It is possible to make these similarities between the occupational incidence of cases of Rheumatic Disease and the occupational mortality from Arthritis more clear by calculating Comparative Morbidity Ratios for each of the above occupations and contrasting these Morbidity Ratios with the Occupational Standard Mortality Ratios (shown in Table D.) for similar occupations. This is done in Tables H and K. It is true that the results of this comparison should be treated with reserve on account of the relatively small numbers of cases included in the Ministry's survey. Nevertheless if a general resemblance should be observed between the observed occupational incidence of Morbidity from Rheumatic Disease and Mortality from Arthritis, the hypothesis that there is a causal relation between the non-articular and articular disease would be supported. (See Table H.)

In this table the Comparative Morbidity Ratios are calculated from the following figures:

1. Total Male Population at Risk - 58,000 males. (1)p.15.
2. Total Male Cases of Rheumatism - 1,771 (1) Table 12,p.36.



TABLE H.

Rheumatic Diseases in Males. Comparative Occupational Morbidity Ratios. All Occupied Males taken as 100. (*See also Table K*)  
 Reports on Public Health and Medical Subjects, no. 23 (1924) p. 15. (1) Table 12.  
 Population at Risk 58,000; Number of Rheumatic Cases experienced 1,771.

Occupation.	% Total Occupied. E. & W. (males)	Estimated Males at Risk.	"Expected" Cases.	Actual No. of Cases.	Excess of Actual Cases.	Excess per 1000 males.
General Labourers	2.6	1,508	29.1	242	212.9	141.3
Metal Workers	12.9	7,482	143.56	396	252.4	33.78
Agriculture.	9.9	5,742	111.3	64	- 47.3	- 8.2
Conveying goods etc.	12.2	7,076	137.1	189	51.9	7.3
Mines and Quarries.	9.0	5,220	101.2	128	26.8	5.1
Clerical.	5.8	3,364	65.2	79	13.8	4.1

3. Percentage of each occupation of All Occupied Males in England and Wales (1911).

4. Actual number of cases observed in each occupation.

From these figures are calculated:-

1. Estimated males at risk, in each occupation.
2. Expected or Calculated cases for each occupation.
3. Excess or deficiency of actual cases in each occupation
  - (a) on basis of estimated population,
  - (b) per 1000 males in each occupation.

As a basis of comparison taking All Occupied males as 100, we obtain the 'Comparative Morbidity Ratios' by adding or subtracting the observed occupational rate per 1000, to or from 100.

(c) In Table K these Comparative Morbidity Ratio are set side by side with the observed Occupational Standardised Mortality Ratio from Arthritis (Table D.)

Comment.

Taken as a whole, the striking similarities observed between the occupational incidence of Rheumatic Diseases in a representative sample of male industrial workers in England and Wales, and the Standardised Arthritis Mortality Ratios in Males in England and Wales, can hardly be explained by chance. Nor is it possible that the similarities are due to the fact that the occupational incidence of the Rheumatic Diseases as a whole is determined by the occupational incidence of the Arthritic Rheumatisms. For if the incidence of Arthritis determined the occupational incidence of the Rheumatic Diseases as a whole, we should find that the bulk of the Rheumatic Diseases consisted of

TABLE K. (see also Table H.)

A.

Occupational Incidence of the Rheumatic Diseases. (1)p.36-7. (†Table H.)  
*above*

Occupation.	Comparative Morbidity Rate.
General Labourers.	241.3
Metal Workers.	133.8
Agriculture.	191.8
Conveying Goods etc.	107.3
Mines & Quarries.	105.1
Clerical.	104.1
All Occupied Males.	100.0

B.

Occupational Incidence of Arthritis Mortalities (see Table D.)

Occupations.	Standardised Mortality Ratios.
General Labourers.	166.5
Metal workers (Hot)	110.0
Farmers & Agricultural workers.	99.0
Bus & Tram Drivers and Conductors.	90.4
Coal Miners.	83.5
Clerks.	87.7
All Occupied Males.	100.0

cases of Arthritis. In fact, the bulk of the Rheumatic Diseases consist of the non-articular rheumatisms. In Chapter 3. above we observed that Arthritis contributed only a quarter of the total cases in the Ministry's survey, and that 67% were classified as non-articular.

#### Conclusion.

It is reasonable to suggest, therefore, that the observed similarities between the occupational case-incidence of the Rheumatic Diseases in the Ministry Report No.23 and the relative occupational Arthritis Mortality Ratios observed in this study, provide evidence of an aetiological connection between the non-articular and the articular Rheumatic Diseases. As to the extent of that connection this study provides no clear indication. It only suggests that that causal relation could perhaps be discriminated by a more detailed and comprehensive study of the Rheumatic Diseases from the occupational point of view.

SUMMARY.Chapter 1.

This investigation was undertaken in the hope of being able to answer the question "What evidence is there that occupation is an important factor in the aetiology of the Rheumatic Diseases?"

Hitherto a causal connection has been asserted on clinical grounds to exist, but the occupations of risk have not been clearly discriminated. The economic aspects of 'industrial rheumatism' are as important as the medical and scientific aspects of it. Industrial Rheumatism is a misleading term. The classification of the Rheumatic Diseases into (a) Acute Rheumatism and its sequelae, (b) the Non-articular Rheumatic Diseases, and (c) The Arthritic Rheumatic Diseases, is accepted. The question is asked "Are these three, or any of these three, types of Rheumatic Diseases causally connected?"

Chapter 2.

The material studied in this paper is (1) Clinical evidence, (2) certain Morbidity Statistics derived from the sickness records of a Food Factory and the General Post Office, (3) the Mortality experience during the years 1921-3 in England and Wales. The last material is derived from the Registrar-General's Decennial Supplement, Part II. Occupational Mortality.

It is found that the clinical evidence points to four groups of occupations in which an excess of the Rheumatic Diseases are found. Occupations involving exposure (a) to weather, (b) to damp, (c) to repeated pressures, shocks, and traumata, and (d) to lead absorption.



### Chapter 3.

Morbidity Statistics. The absence of comparable sickness records in industry is emphasised, nevertheless a little apparently relevant material has been obtained. This material is examined. It is found that it supports the hypothesis that the conditions of work experienced by Postmen when compared with the conditions experienced by indoor postal workers and by Food Factory workers, appear to exert an adverse influence upon the incidence of incapacity from the Rheumatic Diseases. In the absence of any other factor which can account for this difference, the hypothesis is advanced that the most probable influence is exposure to the weather and to damp.

### Chapter 4.

When the mortality statistics are examined, a number of fallacies have to be avoided. Each of these fallacies is discussed and it is determined to restrict the investigation to deaths of Males, over 45 years of age, from Chronic Rheumatism, Arthritis and Gout, in England and Wales during the period 1921-3. Standardised Mortality Ratios are used. The reliability and value of this material is examined and it is considered whether mortalities from Arthritis are a measure of the incidence of Arthritic Disease. The possibly disturbing influence of Social State and All Causes Mortality experience is examined and the kind of allowances that must be made for these factors is indicated.

### Chapter 5.

The statistical material is analysed on a basis of occupation groups which are believed to be comparable with one

another in the light of industrial experience. The Arthritis Standardised Mortality Ratios are determined and compared with that of 'All Occupied and Retired Civilian Males'. Six occupation groups are found to show significantly high Mortality Ratios. There are three groups with unexpectedly but not significantly low Mortality Ratios. The probable connection between Arthritis Mortality and exposure and damp is discussed in the light of these findings.

#### Chapter 6.

It is noted that the low Mortality Ratios are observed (almost exclusively) among Indoor workers.

#### Chapter 7.

The occupations with high mortality experience are discussed in detail. The probable influence of exposure, damp, and exposure to Lead Risks emerge still more definitely. Three groups that do not conform to this hypothesis are indicated. Discussion of these groups is postponed.

#### Chapter 8.

Accepting the hypothesis that exposure to damp is the most important single aetiological occupational factor, three 'composite' groups are arranged according to the degrees of exposure that are experienced in them. This examination is found to conform to the original hypothesis.

#### Chapter 9.

A possible relation between deficient calcium intake and excessive Arthritis Mortality had been inferred from a study of the mortality figures of certain occupations in which Lime Dust was inhaled. Such a relation could explain one or more of the

apparent anomalies observed in the Mortality Tables. A composite occupation group was prepared. This group was composed of workers exposed to Lime Dust at their work. It was found that this group showed a remarkably low ratio. This was consistent (at the least) with the hypothesis that excessive Arthritis Mortality is related to deficient Calcium Intake.

#### Chapter 10.

Finally, the results obtained from an occupational analysis of the General Practitioners' Enquiry (The Incidence of Rheumatic Diseases) showed that the non-articular rheumatisms were unduly prevalent in certain occupations. Our analysis of the Arthritis Mortality Ratios on an occupational basis showed that these ratios were in general high in the same or comparable occupations. It is considered whether the results derived from these two sources are in sufficient agreement to suggest that there is an aetiological relation between these two types of rheumatic disease.

The Conclusions derived from this enquiry are stated, and a Bibliography and acknowledgements are appended.

Conclusions.

1. General conclusions.

(a) All of the evidence, clinical and statistical, that has been collected and analysed in this paper tended to show that there were certain industrial or occupational factors in the aetiology of the Chronic Arthritic Diseases and that those same factors were possibly of importance also in the aetiology of the Fibrositic Diseases.

(b) At the same time, the evidence strongly suggested that 'industrial rheumatism' - in the sense of the Rheumatic Diseases from which the industrial workers suffer - was determined more by Social (and perhaps by personal) factors than by strictly occupational factors.

(c) If these conclusions were sound, the practical outcome of this study would be that Industry ought not to be expected or asked to shoulder the financial burden of the whole of Industrial Rheumatism. It should be held responsible only for that part of the whole mass of the Rheumatic Diseases in which a clear and significant industrial factor can be shown to be at work.

(d) From the scientific and medical points of view, the most important conclusions to be drawn concern the unanimity with which the clinical evidence, the sickness records and the Chronic Arthritis Mortality records point to 'exposure to damp' as the most important, strictly occupational, factor in the aetiology of Chronic Arthritis, and perhaps in the aetiology of the Fibrositic Rheumatisms.

## 2. Particular conclusions.

### (a) The Fibrositic Diseases.

The material surveyed was manifestly inadequate for final conclusions to be drawn from it in respect of the Fibrositic Rheumatisms. Many more comparable and accurate sickness records would have to be collected and analysed before a final conclusion could be reached concerning the occupational factor in the Fibrositic Rheumatic Diseases. Nevertheless, the evidence points in one direction, namely, towards exposure to the weather and especially to the damp as the most important significant occupational factors in the aetiology of the Fibrositic Rheumatic Diseases.

### (b) The Chronic Arthritis Diseases.

When we considered the results of the analysis of the occupational trends of mortalities from Chronic Arthritis amongst males observed in certain occupations in England and Wales during the years 1921-23, somewhat more definite conclusions were obtained. Time alone can show whether similar trends will be observed when the 1931 Census figures are published. In the meanwhile, the following conclusions appeared to be justified concerning Occupation and Chronic Arthritis.

On the basis of the probable hypothesis (which we have examined) that Arthritis Mortality experience reflected the general incidence of Chronic Arthritis, we concluded:

- (i) That the whole of the industrial population of England and Wales (1921-3) suffered from the Chronic Arthritic Diseases at a remarkably uniform rate, and that the chief



factors which appeared to determine the differential incidence of Chronic Arthritis were Social and Economic rather than industrial in origin.

(ii) Nevertheless, that there were six occupations in which occupational factors appeared to be at work to produce a significant excess of mortality from this cause.

(iii) That these groups were:

- (a) Painters and Decorators,
- (b) Horse Transport workers,
- (c) Certain Miners and Quarry workers  
(not Coal nor Limestone),
- (d) Brewers,
- (e) General Labourers, and
- (f) Textile workers.

(iv) That two other groups showed an excess mortality from Chronic Arthritis which might be attributable to occupation, namely:

- (a) Chemical and Dye workers, and
- (b) Dock workers.

(v) That no occupations were observed in which there was significant evidence of an under-average incidence of deaths from Chronic Arthritis, but that the Retail Business group showed some evidence of an under-average mortality. This was an Indoor occupation.

(vi) That there was no evidence that Farmers suffered from an excessive mortality from Arthritis.

(vii) That with certain exceptions (which were discussed in detail),

- (a) All occupations which showed High Arthritis Standardised Mortality Ratios were 'out-of-doors' occupations.

- (b) All occupations which showed low Arthritis Standardised Mortality Ratios were Indoor occupations.
- (viii) That both clinical experience and statistical evidence suggested that Chronic Lead absorption probably accounted for the excessive incidence of Chronic Arthritis observed amongst Painters and Decorators.
- (ix) That work in a damp, humid atmosphere amongst certain Indoor workers or exposure to wet weather whilst at work, amongst Outdoor workers formed the most important single 'industrial factor' in the production of Chronic Arthritis.
- (x) That there was some clinical and statistical evidence that the absorption of Lime whilst at work might exercise a beneficial influence upon the incidence of Chronic Arthritis.
- (xi) That the only other beneficial occupational influence which was observed was 'indoor' work.
- (xii) That there was evidence that there is a relationship between the occupational incidence of the Rheumatic Diseases and the occupational incidence of deaths from Arthritis.
- (xiii) That nevertheless considerable caution ought to be exercised before Chronic Arthritis or the Rheumatic Diseases as a whole could be directly attributed to Occupation in the existing state of our knowledge.

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